*भारतीय मानक*
***Indian Standard***

**IS 16482 : 2018**

# स्पंज आयरन के उत्पाद के लिए कोयला गैसीफायर से संश्लेषण गैस का इस्तेमाल — दिशानिर्देश

# Use of Synthesis Gas from Coal Gasifier for Production of Sponge Iron — Guidelines

ICS 73.060.10

© BIS 2018

भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS
मानक भवन, 9 बहादुरशाह ज़फर मार्ग, नई दिल्ली-110002
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI-110002
www.bis.org.in www.standardsbis.in

**January 2018** **Price Group 1**

Sponge Iron and Smelting Reduction Sectional Committee, MTD 30

## Foreword

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Sponge Iron and Smelting Reduction Sectional Committee had been approved by the Metallurgical Engineering Division Council.

In regions with high natural gas costs or limited availability of natural gas, use of coal gasification (if coal is available in abundance) to generate necessary reducing gases and combining it with a traditional shaft type sponge iron reactor for production of sponge iron, may provide an alternative commercially attractive proposition.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

# *Indian Standard*

# USE OF SYNTHESIS GAS FROM COAL GASIFIER FOR PRODUCTION OF SPONGE IRON — GUIDELINES

## 1 SCOPE

**1.1** This standard covers the requirements of synthesis gas from coal gasifier for gas based direct reduction, as desired by the established processes, namely Midrex, HYL, Energiron, etc, in commercial operation, for the production of steel making grade direct reduced iron (DRI).

**1.2** Requirements covered in this standard shall be met at the point of receipt, unless it is stated otherwise.

## 2 COAL GASIFICATION AND GENERATION OF SYNTHESIS GAS

### 2.1 Coal Gasification

**2.1.1** In general, coal gasification can be defined as a partial oxidation process in which a carbonaceous fuel (liquid or solid) reacts at high temperature and at atmospheric/high pressure with air/oxygen and steam, called gasifying agent, to produce a synthesis gas or syn gas. The synthesis gas contains mostly hydrogen ($H_2$), carbon monoxide (CO) and methane ($CH_4$) but also some water vapour ($H_2O$), carbon dioxide ($CO_2$), nitrogen ($N_2$) and sulphur compounds ($H_2S$ and COS) and sometimes, other by-products, depending on the gasification technology employed and feed used. Though a wide range of carbonaceous fuels can ostensibly be used in gasifiers, the most commonly used feed materials are coal, petroleum coke and petroleum refinery residues (tars, heavy fuel oils, etc). Though all types of coal – brown coal (lignite), sub-bituminous coal, bituminous coal and even anthracite can be used for gasification, high grade coal is normally not used. Gasification is best applied to low cost coal that otherwise cannot be used.

**2.1.2** Different types of commercial gasifiers have been in operation for over 50 years. While there are some distinct differences between one type of gasifier and the other, they all operate on the same basic principles.

**2.1.3** There are three general types of gasifiers namely, Fixed bed, Fluidized bed and Entrained bed and all of them can generate gas that is technically acceptable as reducing gas for shaft furnace direct reduction after some amount of composition/volume/pressure adjustments.

**2.1.4** In a fixed bed or fluidized bed gasifier, ash in coal is left over as residue, which has to be periodically disposed off. In the third type of gasifiers, that is entrained bed gasifiers, a totally different approach involving much higher temperatures generated by the introduction of oxygen in controlled amounts is employed. Oxygen accelerates partial combustion of coal and at the high temperatures, the ash in coal forms a liquid slag that can be drained, either continuously or periodically.

**2.1.5** The entrained bed and fixed bed gasification technologies are by far the most commonly used for producing syngas for DR rather than fluidized bed processes where the size range of coal that can be gasified is restricted.

**2.1.6** In an entrained bed gasifier, the finely ground carbonaceous feedstock and gasifying medium are continuously fed co-currently into either the top or bottom of the gasifier. The feedstock and gasifying agent react at a high temperature to produce the syngas. The reactor temperature is high enough to melt the ash components from the carbonaceous materials, which are discharged from the bottom of the gasifier as an inert slag, either intermittently or continuously. The dominant entrained bed gasification technology suppliers are shell, GE (formerly Texaco) and Conoco Philips.

**2.1.7** In a fixed bed gasifier, coal is added to the top of the reactor *via* a lock hopper and gasifying agent (oxygen + steam) is continuously fed to the bottom of the reactor. As the coal descends, it is gasified by the counterflowing gasifying agent. The solid ash is discharged from the bottom of the gasifier *via* a lock hopper. Most fixed bed gasifiers are designed to operate at a temperature below the ash melting point. The dominant fixed bed gasification technology supplier is Sasol Lurgi.

**2.1.8** The syngas produced in the gasifier requires cleaning to remove tar, phenols, ammonia, etc, and conditioning before it becomes suitable for use in sponge iron shaft type reactors. The majority of the acid gases ($H_2S$, COS and $CO_2$) are removed from the syngas by an amine-type acid gas removal system. The concentrated sulphur gases are further treated to convert them into saleable elemental sulphur.

**2.1.9** In case of a fixed bed gasifier, additional unit operations are required to remove tar, phenols, ammonia, etc, from the syngas, all of which have to be disposed off as by-products.

**2.1.10** Because of high ash fusion temperature of Indian coal, dry bottom fixed bed technology is preferred in Indian context. Besides, the technology allows use of high ash coal that is up to 40 percent and no coal drying and grinding is required.

### 2.2 Quality Requirements

**2.2.1** *Guidelines on Coal Characteristics*

Coal is generally accepted to be the most heterogeneous natural resource and coal properties can vary extensively between geographical sites and even within the same regional location. Accordingly, coal properties will, to a large extent, determine the gasifier design, performance and stability as well as requirements of equipment and downstream process units. Therefore, determination of coal gasification characteristics and their comparison with historical /benchmark data is an important requirement.

The following tests are generally required to be made to determine the suitability of coal for gasification purposes:

> Proximate analysis, Ultimate analysis, Heating value analysis, Total sulphur analysis, Particle size distribution analysis, $CO_2$ gasification reactivity, Ash fusion property analysis, Ash composition analysis, Fischer assay analysis, Caking property analysis, Thermal fragmentation analysis, Mechanical fragmentation analysis and Maceral (Petrographic composition and coal rank) analysis, etc.

Tests for suitability of coal for gasification should be carried out in the test gasifiers for which necessary service is provided by the technology suppliers.

**2.2.2** *Gas Quality Criteria for Use in Shaft Furnace DR*

a) The gas analysis should match the requirements of DR unit as closely as possible.

b) The gas pressure and temperature must also be able to meet the DR process requirements.

c) The gas must contain very little carbon dioxide (less than 2 percent) & sulphur (< 25 ppm).

d) Idling and load changing behaviour of the gasifier should be similar to that of the DR unit.

**2.2.3** The major quality parameters of syn gas are the $H_2$/CO ratio, oxidants/reductants ratio, methane ($CH_4$), sulphur contents and proportion of hydrocarbon heavier than methane. Proper $H_2$/CO and oxidants/reductants ratio are desired to ensure thermally balanced reduction reactions and optimum reduction potential (gas quality) respectively. Extent of methane content permitted shall depend on the in-situ reforming possible within the reactor at the reduction zone and product quality desired. Unlike natural gas based DR plant, a relatively higher sulphur content in the gas can be accepted. However, its content is limited by the overall sulphur balance of the process.

**2.2.4** The syn gas quality required for optimal performance of gas based DR plant is as given below:

| *Sl No.* | *Parameter* | *Desired* | *Acceptable* |
|---|---|---|---|
| i) | $H_2$ / CO Ratio | > 0.50 | 0.5 - 4.0 |
| ii) | Reductant / Oxidant Ratio or [(%$H_2$+%CO)/(%$H_2O$ + %$CO_2$)] | 10 (*Min*) | >2.0 |
| iii) | $CH_4$ content | 3 - 8 percent | 0-15 percent |
| iv) | $C_2$, $C_3$+, etc | < 1 % | < 1 percent |
| v) | $CO_2$ content | Up to 3 percent (*Max*) | Up to 3 percent (*Max*) |
| vi) | Water | Trace | Trace |
| vii) | $H_2S$ | 50 ppmv (*Max*) | 100 ppmv (*Max*) |
| viii) | COS | 5 ppmv (*Max*) | 5 ppmv (*Max*) |
| ix) | $N_2$ + Ar | <1 percent | < 5 percent |
| x) | Temperature | $30^o$ C (*Min*) | 30° C (*Min*) |
| xi) | Pressure | 4-10 bar g | 4-29 bar g |
| xii) | Soot | <100 mg/$Nm^3$ | <1 000 mg/$Nm^3$ |
| xiii) | Dimension of suspended particle | <10 µm | <10 µm |
| xiv) | Net calorific value | 3 200 - 3 550 Kcal/$Nm^3$ | 2 600 - 3 550 Kcal/$Nm^3$ |
| xv) | Gross calorific value | 3 500 - 4 000 Kcal/$Nm^3$ | 2 900 - 4 000 Kcal/$Nm^3$ |

**Bureau of Indian Standards**

BIS is a statutory institution established under the *Bureau of Indian Standards Act*, 1986 to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

**Copyright**

BIS has the copyright of all its publications. No part of these publications may be reproduced in any form without the prior permission in writing of BIS. This does not preclude the free use, in the course of implementing the standard, of necessary details, such as symbols and sizes, type or grade designations. Enquiries relating to copyright be addressed to the Director (Publications), BIS.

**Review of Indian Standards**

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Catalogue' and 'Standards : Monthly Additions'.

This Indian Standard has been developed from Doc No.: MTD 30 (5175).

**Amendments Issued Since Publication**

| Amend No. | Date of Issue | Text Affected |
|---|---|---|
| | | |
| | | |
| | | |
| | | |

BUREAU OF INDIAN STANDARDS

**Headquarters:**

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
*Telephones* : 2323 0131, 2323 3375, 2323 9402 *Website*: www.bis.org.in

| **Regional Offices:** | | *Telephones* |
|---|---|---|
| Central | : Manak Bhavan, 9 Bahadur Shah Zafar Marg<br>NEW DELHI 110002 | 2323 7617<br>2323 3841 |
| Eastern | : 1/14 C.I.T. Scheme VII M, V. I. P. Road, Kankurgachi<br>KOLKATA 700054 | 2337 8499, 2337 8561<br>2337 8626, 2337 9120 |
| Northern | : Plot No. 4-A, Sector 27-B, Madhya Marg, CHANDIGARH 160019 | 26 50206<br>265 0290 |
| Southern | : C.I.T. Campus, IV Cross Road, CHENNAI 600113 | 2254 1216, 2254 1442<br>2254 2519, 2254 2315 |
| Western | : Manakalaya, E9 MIDC, Marol, Andheri (East)<br>MUMBAI 400093 | 2832 9295, 2832 7858<br>2832 7891, 2832 7892 |

**Branches:** AHMEDABAD. BENGALURU. BHOPAL. BHUBANESHWAR. COIMBATORE. DEHRADUN. DURGAPUR. FARIDABAD. GHAZIABAD. GUWAHATI. HYDERABAD. JAIPUR. JAMSHEDPUR. KOCHI. LUCKNOW. NAGPUR. PARWANOO. PATNA. PUNE. RAIPUR. RAJKOT. VISAKHAPATNAM.

Published by BIS, New Delhi